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FLIGHT TEST OF ANTI-KNOCK INJECTOR

(POWER PLANT SECTION REPORT)

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FLIGHT TEST OF ANTI-KNOCK INJECTOR.

OBJECT OF TEST.

The object of this test was to determine if the injection of an antidetonating compound into the manifold of an engine is practicable.

SUMMARY.

When the injector was in working order and set to feed the proper amount of compound, detonation appeared to be eliminated except during acceleration. Due to mechanical troubles in the injector and imperfections in its action, in the form in which it was tested, the research work was discontinued.

CONCLUSIONS.

The effective injection of antidetonating compound is possible, but further experimentation is not recommended until it has been definitely shown that this method of introducing the compound is necessary. At the present time it appears that mixing the compound with the fuel in the tanks is to be preferred, due to the absence of mechanical complication.

INTRODUCTION.

Some experiments have been carried on by the Engineering Division with antidetonating compounds, but they have not proved entirely satisfactory because the compounds have been more or less poisonous and consequently dangerous to handle, because the compounds caused serious corrosion of the fuel tanks and piping, and finally because they are very expensive.

It was hoped that the injection of antiknock at the intake manifolds, at relatively high power operation at low altitudes only, would avoid the waste of compound and prevent the injury to fuel tanks and lines now encountered when mixing the antiknock with the gasoline. An injecting device to accomplish these results was therefore constructed.

DESCRIPTION.

The device tested was manufactured by the General Motors Research Corporation, of Moraine City, Ohio. It is constructed of a cast-iron body which incorporates a brass float chamber somewhat similar to that of a carburetor. The delivery passage from the float chamber is controlled by a sleeve valve operated by an aneroid (see fig. 5). The principle of the device is to admit antidetonating compound directly into the manifold as near the cylinders as possible during full throttle operation and an extra large quantity at the moment of acceleration. The compound or solution, which in this case was xylidine, flows through the inlet shown on the drawing, and the level in the chamber is regulated by a cork float (balsa wood was later substituted by the engineering division). Two holes drilled at A meter the maximum amount of xylidine fed by the injector. The valve B, as the drawing indicates, is actuated by the aneroid, which in turn reacts to the manifold depression. As the throttle is opened the depression decreases until the valve B opens. This depression, when the valve is open, causes the xylidine to flow into the manifold and mix with the incoming charge. If the throttle is closed the depression increases and closes the valve B. A well C is provided for the purpose of delivering a relatively large quantity of the compound during acceleration. This was later supplemented by an additional well D.

The adjustment of the instrument is such that the valve B starts to open when the absolute pressure in the aneroid chamber reaches 20 inches of mercury. As the pressure increases above this point the valve opening increases, until at an absolute pressure of about 28 inches of mercury the valve B is wide open and the fuel is metered by orifice A.

The pressure in the engine manifold is governed both by the throttle opening and the atmospheric pressure. Above an altitude of about 10,000 feet the pressure in the manifold is always less than 20 inches Hg, and consequently no compound would be delivered. Twenty-eight inches Hg pressure in the manifold corresponds to full throttle opening at sea level.

METHOD OF TEST.

A Liberty "12" engine, standard except for pistons, which had a compression ratio of 6½:1, was installed in a DH-4B airplane. The entire test was conducted in the airplane on the ground and in flight, with aviation gasoline War Department Specification No. 2-40.

The test was conducted with the following groups of equipment:

1. Four dope injectors were installed, each independent and feeding one manifold, drawing the xylidine from a small tank placed at and above No. 5 left cylinder.
2. One dope injector feeding all the manifolds and supplied by the same tank mentioned above but located on the center section of the airplane.
3. One dope injector and tank as before with the addition of four distributor valves, illustrated in Figure 1, which metered the amount of compound to be supplied each manifold.
4. The same arrangement as mentioned under item No. 3 except for the substitution of a 5-gallon tank.

Ground tests consisted of accelerating rapidly and running the engine full out, meanwhile listening for any detonation. When the distributor valves shown in Figure 1 were installed the flow was observed through the

sight gauges. The aërial tests consisted of level flights which were made around 2,000 feet and of 30 or 40 minutes' duration. Here again observations of detonation were made. This routine was carried out with each change of equipment. After landing, the spark plugs were inspected. The flights to determine the consumption were made as follows:

(*a*) Climb at full throttle to 3,000 feet altitude and fly level at full throttle. The total duration of a flight, including the climb, should be one hour.

(*b*) Make a similar flight at 1,500 revolutions per minute. Climb should be made at full throttle.

RESULTS OF TEST.

The difficulties may be summarized under two heads, viz., operative troubles not attributable to the injector and mechanical troubles in the injector itself.

When the flights were made with four injectors, it was found that the porcelain spark plugs failed by cracking of the insulator and burned electrodes, such as is usually the case with high-compression engines when detonation is severe. The failures appeared to be largely confined to the right front manifold. The right rear manifold appeared to be receiving an excess of xylidine, indicating that the distribution was not equalized. For this reason, one injector was advocated. It was also believed that more consistent operation would be obtained by moving the xylidine tank from its position on the engine to the center section of the airplane, to increase the fuel head. A single injector was finally installed between No. 1 right and left cylinders. Further flights with this arrangement showed that detonation was still present and that the distribution to the various manifolds was not uniform. Detonation was also observed when accelerating the engine from idling speed. To observe the distribution and operation of the injector during acceleration, four distributor valves were installed between the injector and the manifolds. At the same time the feed lines from the injector to the manifolds were shortened about 12 or 14 inches to an irreducible minimum with the existing equipment. This change was made to prevent any lag of the xylidine during acceleration. A one-hour flight was attempted to measure the amount of xylidine used, but the 1-gallon tank proved of insufficient capacity and a 5-gallon tank was therefore substituted. The flights were then made, the results of which are noted later in this report.

Several mechanical difficulties occurred. The cork floats used in the single injector expanded and became jammed in the float chamber or lost their buoyancy by absorbing the compound used to eliminate detonation. The float needle valve became gummed up and jammed several times. The instrument therefore flooded and leaked over the top of the float bowl and a considerable amount of xylidine flowed into the aneroid chamber. To overcome the troubles with the float, experiments were conducted with balsa wood. A piece of cork and one of balsa wood, both untreated, were placed in a container of xylidine for 20 days. The dimensions of the 2 pieces before and after this period of immersion were as follows:

	Cork.	Balsa wood.
Before immersion.........	[illegible] inch × 1 inch × 1[illegible] inches.	1 inch × 1 inch × 1 inch.
After immersion..........	[illegible] inch × 1[illegible] inches × 1[illegible] inches.	1$\frac{1}{32}$ inches × 1$\frac{1}{32}$ inches × 1 inch.

The expansion of the balsa wood was scarcely appreciable, while the cork expansion was extreme. The cork had also lost its buoyancy so that the top surface was almost immersed. The balsa wood, on the other hand, was apparently as buoyant as before tested. The test pieces were broken and the cork was found saturated throughout, while the balsa wood contained a considerable area at the center which was perfectly dry. The comparative value of these two articles for float material is shown by the much more satisfactory performance of the balsa wood in the present injector when one was installed on the injector during this test.

In tightening the nut on the bottom of the float chamber bowl to prevent leakage, the drilled cast-iron boss was broken off on several of the injectors tested.

The following consumption of xylidine and fuel was observed in flight:

Duratin of flight, 1 hour; altitude, 3,000 feet; full throttle, 1,740 revolutions per minute:

Fuel consumed	gallons..	34
Xylidine consumed	quarts..	5
Per cent, by volume, of xylidine to total fuel used		3.5

Duration of flight, 62 minutes; altitude, 3,000 feet; throttled to 1,500 revolutions per minute:

Fuel consumed	gallons..	25
Xylidine consumed	quarts..	3
Per cent, by volume, of xylidine to total fuel used		2.9

ANALYSIS.

The tests have shown that this method of injection is sound and can be worked out in a satisfactory manner, possibly with better economy of the compound than by any other method. It has further been shown that the present means for accomplishing the injection of antiknock compounds is unsatisfactory from a mechanical standpoint. It is suggested that an injector should be so constructed as to preclude the possibility of leakage on any part of the engine or airplane from high-grade materials able to withstand the usage to which it is subjected in service. The float mechanism should be positive in action and reliable. Any possibility of the antidetonating solution reaching the aneroid should be prevented. The amount of the xylidine found necessary in laboratory tests was 5 per cent by volume, so that the unit used effected a saving of 30 per cent of the compound at full throttle, 3,000 feet altitude.

Cheaper compounds are now being developed, and it is probable that the mixing of these with the fuel will be practicable. On account of the mechanical complication of the injection method, it is recommended that no further research work be conducted at the present time.

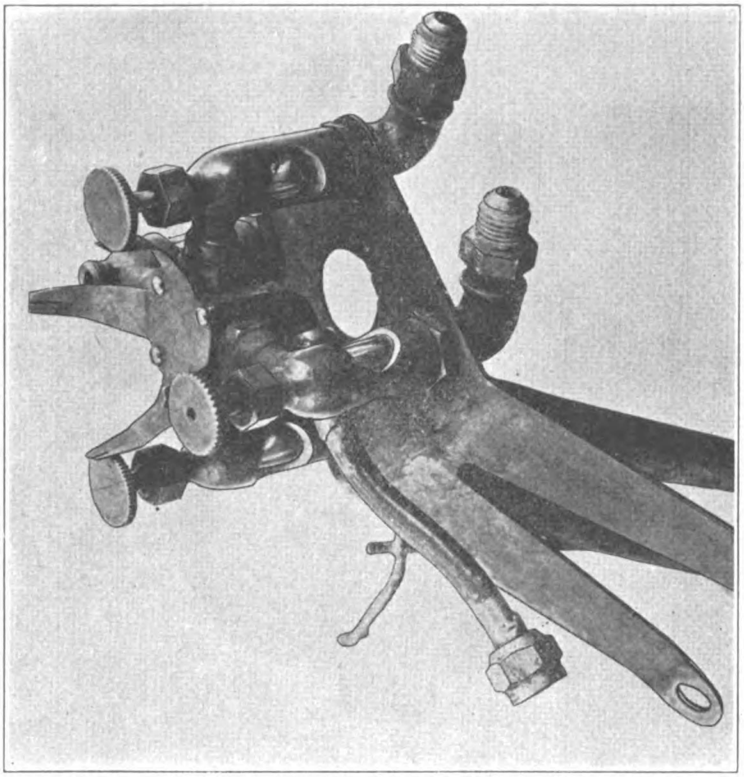

Fig. 1.—Distributor valves with sight gages.

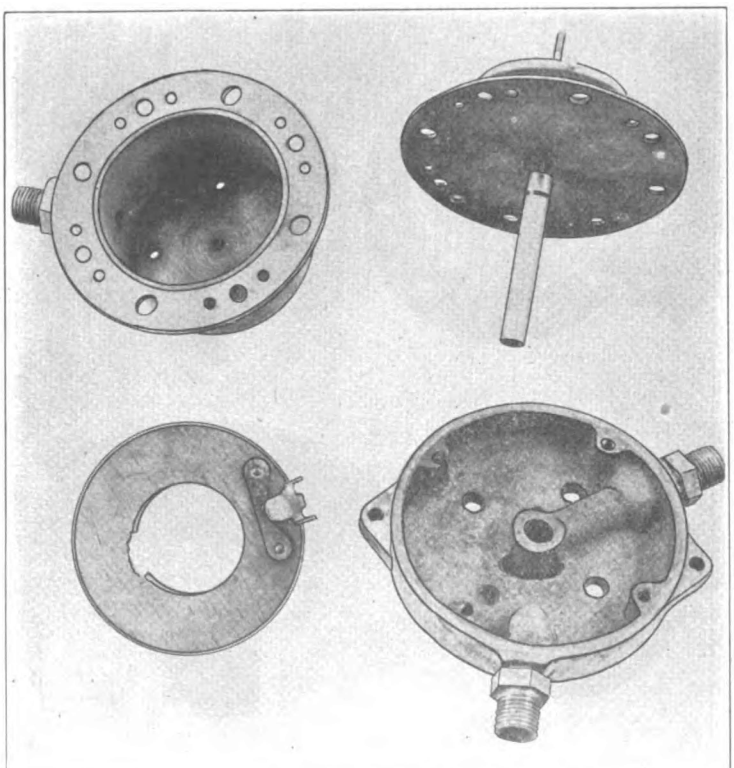

Fig. 2.—Anti-knock injector details.

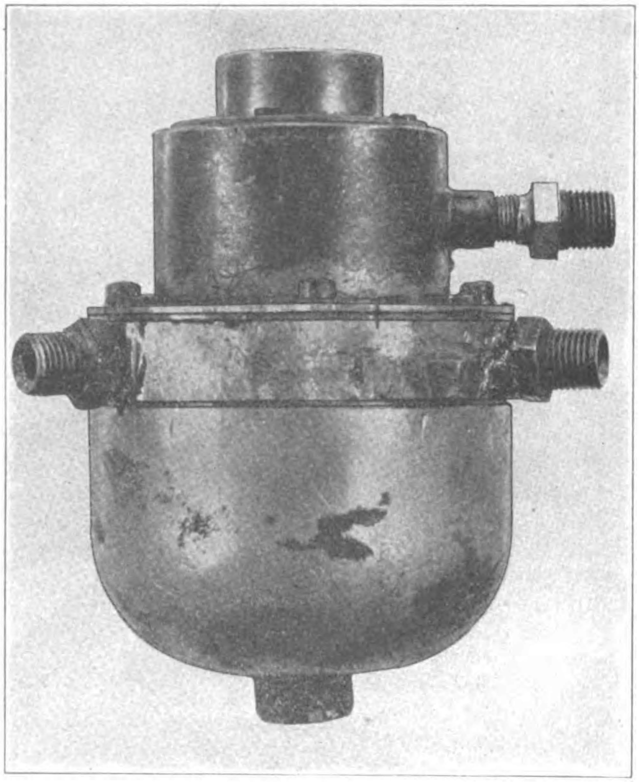

FIG. 3.—Anti-knock injector assembly.

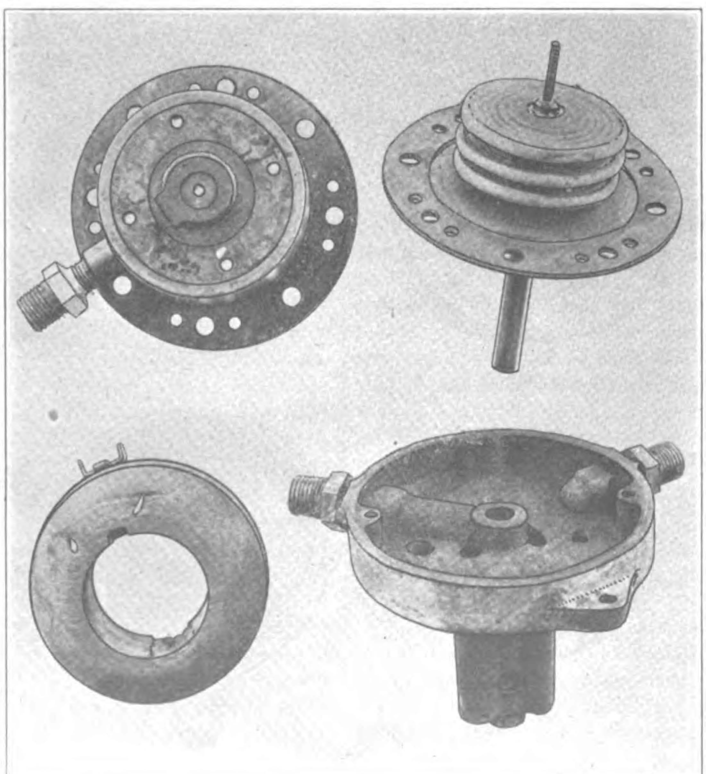

FIG. 4.—Anti-knock injector details.

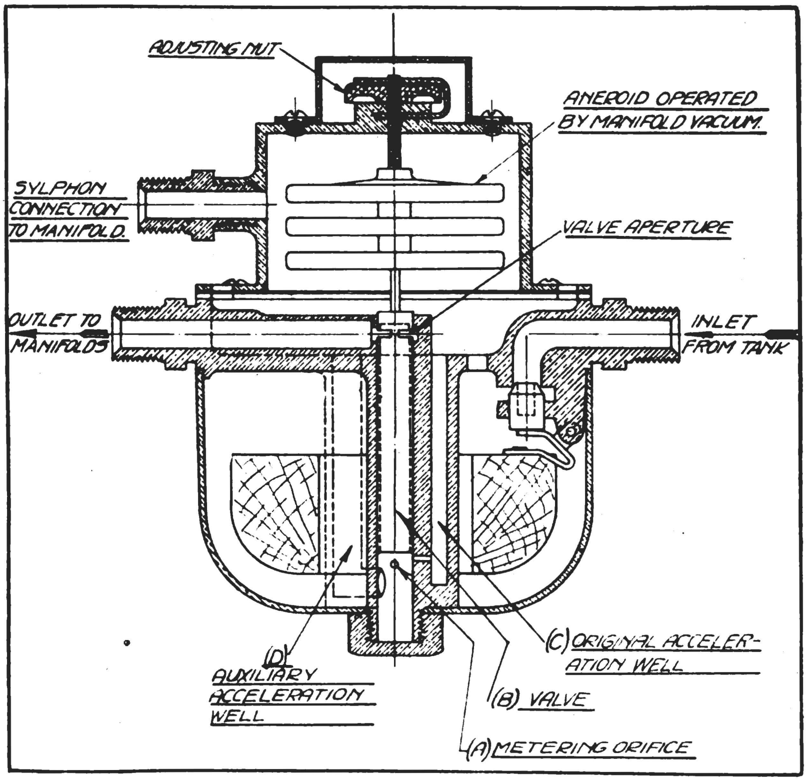

FIG. 5.—Diagrammatic cross sectional view of anti-knock injector.

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